STATE OF CALIFORNIA

AIR RESOURCES BOARD

QUALITY ASSURANCE

VOLUME II

STANDARD OPERATING PROCEDURES FOR AIR QUALITY MONITORING

APPENDIX U

METEOROLOGICAL PARAMETERS PERCENT RELATIVE HUMIDITY SENSORS

MONITORING AND LABORATORY DIVISION

JANUARY l995

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AIR RESOURCES BOARD

QUALITY ASSURANCE

VOLUME II

STANDARD OPERATING PROCEDURES FOR AIR QUALITY MONITORING

APPENDIX U.1

METEOROLOGICAL PARAMETERS PERCENT RELATIVE HUMIDITY SENSORS

MONITORING AND LABORATORY DIVISION

OCTOBER 1997

U.1.0 GENERAL INFORMATION

U.1.0.1 INTRODUCTION

Percent relative humidity (%RH) is a meteorological parameter that is associated with the implementation of the California Air Resources Board (CARB) Volume II, of the Air Monitoring Quality Assurance Manual, Method V, "Instrumental Measurement of Visibility Reducing Particles". The following procedure will apply to sensors made by Rotronic Instrument Corporation and Met One Instrument Corporation. These procedures consist of daily, biweekly, and semiannual checks performed by the station operator. This document can also be used as a guide in working on other manufacturers' instruments which measure %RH.

U.1.0.2 INSTRUMENTATION

First Level Quality Control Check:

Rotronic Hygroskop GT-L or Environmental Tectonics Psychro-Dyne Dry Bulb/Wet Bulb Psychrometer.

Measurement:

Rotronic MP-100C/TM-12R or Met One 083C.

U.1.0.3 THEORY OF OPERATION

The Rotronic MP-100/TM-12R and the Met One 083C %RH sensors use a small hygroscopic capacitor that modifies its response as a function of both the water vapor pressure and temperature of the environment. The capacitor consists of two porous electrodes that produce a 0-1 volt signal that can be measured by a datalogger/recorder combination. The Rotronic sensor is accurate to within $\pm$2.0 %RH throughout the 0-l00% range within the temperature range of -20 to 50 degrees Centigrade (EC), and the Met One sensor offers accuracy of $\pm$3.0 %RH between 10-90% of range and $\pm$5.0 %RH between 90-100% of range within the temperature range of -40 to 79 EC. The Rotronic sensor generates both the %RH and outside temperature (OTEMP) signals; thus, both parameters will be discussed in this section of the quality control procedures. The Met One %RH and OTEMP sensors are separate units and generate separate signals; thus, only the Met One %RH sensor is discussed here. The Rotronic and Met One sensors are used with the CARB standardized meteorological sensor interconnect (Figure U.1.0.1) and CARB meteorological sensor cable (Figure U.1.0.2).

The Rotronic %RH and OTEMP sensors are mounted within the same assembly; the Met One %RH and OTEMP sensors are individual units and are usually mounted side-by-side. All CARB %RH sensors are mounted within an aspirated shield which protects the sensor from adverse effects from the sun. The Rotronic aspirated shield is powered by 12 volts direct current (VDC) while the Met One shield is powered by 120 volts alternating current (VAC).

All sensors should be mounted at least two meters above the ground. This should provide compliance with the U.S. EPA's Quality Assurance Handbook for Meteorological Measurement, Volume IV (EPA Volume IV).

U.1.0.4 DISCUSSION

%RH and OTEMP can be extremely variable over a relatively short time constant. With respect to atmospheric conditions, both measurements can be affected to different degrees. On cloudy calm days, usually associated with high humidity and lower temperatures, equilibrium between the station sensor and the measuring meter is readily attained within 10 minutes. On sunny, windy days with rapid rise and fall of temperature, equilibrium may not be attained in 10 minutes. Under these conditions, the %RH can continue to fluctuate for an extended time. However, readings should still be recorded from the station sensor and measuring meter within 10 minutes.

Measurements to determine compliance with the visibility standard are accomplished by averaging an 8-hour observation period (9:00 a.m.-5:00 p.m. Pacific Standard Time). Generally, %RH exceeds 70% during nighttime and early morning hours. Considering that instruments are generally more accurate between 20% and 80% of their range, quality control checks should be made sometime during the day when %RH is 80% or lower. The Rotronic Hygroskop GT-L or the psychrometer should be positioned within 5 feet of the mounted aspirated shield. To assist in shortening the amount of time for equilibrium, the measuring meter should be placed outside, away from the sun, for several minutes prior to placing the meter near the %RH sensor.

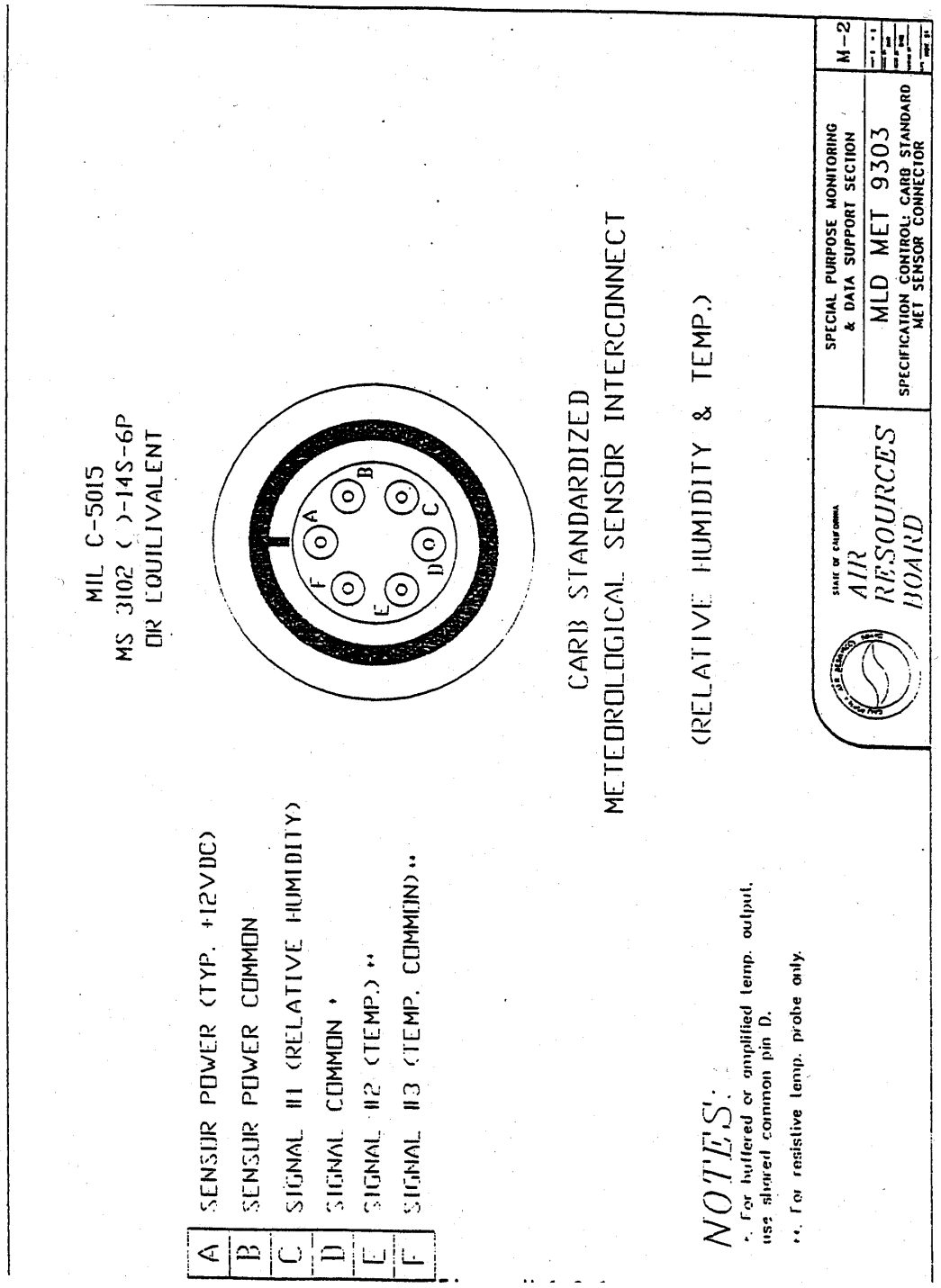

Figure U.1.0.1
CARB Standardized Meteorological Sensor Inerconnect

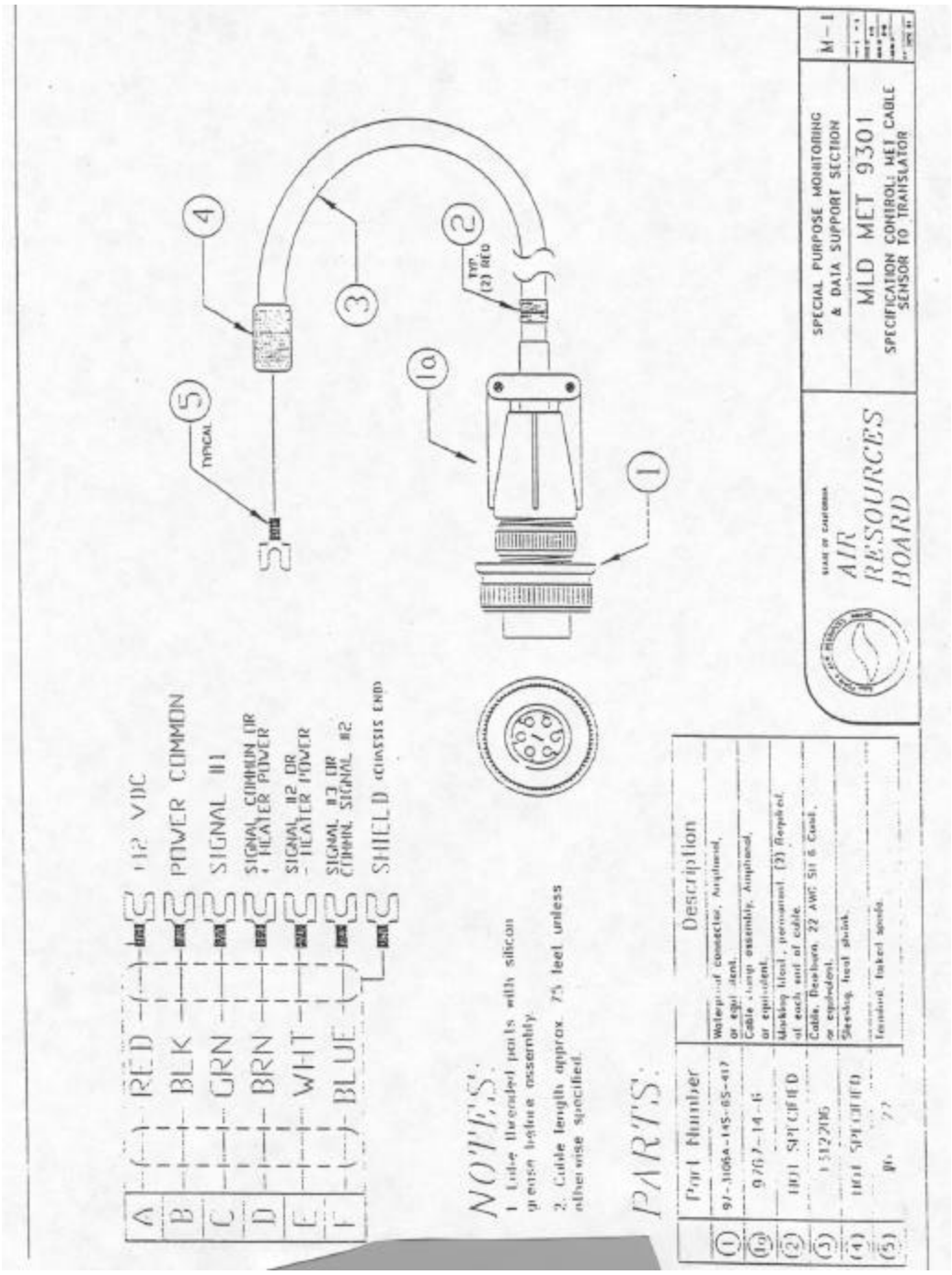

Figure U.1.0.2
CARB Meteorological Sensor Cable

U.1.1 ROUTINE SERVICE CHECKS

U.1.1.1 DAILY CHECKS

On a daily basis, the station operator should look over the %RH data collected for the previous day. The operator should compare the %RH readings with the previous day's weather (i.e., if it rained from 1000 to 1300, the %RH readings should be 100% $\pm$5% for the hours of 1000 through 1300). If the comparisons appear to be bad, the operator should proceed to the monthly checks section of these procedures.

U.1.1.2 BIWEEKLY CHECKS

On a biweekly basis, the station operator should check the aspirated shield to assure that the fan is still operating, thus ensuring enough air is flowing through the radiation shield to prevent it from becoming a heat sink around the sensor. A Met One fan is usually noisy enough to be heard from the ground. However, the Rotronic fan is very quiet, so the operator has to get within five feet of the shield before being able to tell if it is operating. Another method is to install a 12 VDC bulb in line with the current to the fan. If the bulb is not lit and not burned out, the fan is non-operational, and the operator should change it as soon as possible and delete any data collected since the previous check.

On a biweekly basis, the station operator should also check the proper operation of the Met One 083C translator board, and the accuracy of the station %RH sensor against a %RH reference meter. Specific instructions are given for the two styles of %RH reference meters (Rotronic Hygroskop GT-L and Environmental Tectonics Psychro-Dyne Psychrometer). The Rotronic Hygroskop GT-L is the preferred meter to use. The instructions for the %RH reference meters apply to checking the accuracy of both the Rotronic MP-l00C/TM-12R and the Met One 083C station sensors.

1. Met One 083C Translator Board Checks

    a. Open the door to the Met One translator. Depress the Zero switch (S1). After the reading on the datalogger's %RH channel stabilizes, usually within 30 seconds, record this value on the Monthly Quality Control Maintenance Checksheet (Figure U.1.1.1). If the reading does not read between $\pm$0.0 %RH and $\pm$0.5 %RH, refer to the factory operational manual and calibrate the translator board.

b. Release S1 and depress the Full Scale (S2) switch. After thedatalogger reading has stabilized, record this value on the monthly maintenance checksheet. If the reading is not within 99.5 and 100.5 %RH, refer to the factory operational manual and calibrate the translator board.

2. Station's %RH Sensor Accuracy Check Using Rotronic Hygroskop GT-L Reference Meter.

NOTE: Read the instruction manual for the Hygroskop GT-L before proceeding. This unit should be calibrated every six months. The sensor accuracy quality control check should be completed sometime during the day when %RH is below 80%.

a. Place the black On-Off switch in the "On" position. Position the meter within five feet of the radiation shield. Ideally,the meter tip should be inserted into the inlet of the radiation shield, but safe access could make this unfeasible.

NOTE: Protect the meter from direct sunlight during the measurement. Use the white dust filter on the meter tip at all times. This will help protect the capacitance head from damage.

b. Push the white switch to move indicator on the liquid crystal display (LCD) to the "EC" position. Track the temperature until constant.

c. Once the temperature has stabilized, push the white switch to move the indicator on the LCD to the "%RH" position and watch the LCD readout until the reading stabilizes. When stabilized, record %RH on the checksheet (Figure U.1.1.1).

d. Push the white switch to move the indicator on the LCD to the "EC" position and record the temperature on the checksheet.

e. Push the black switch to the "Off" position.

f. Return immediately to the station and record the datalogger's present %RH and OTEMP readings on the checksheet.

g. The Rotronic GT-L %RH should agree within ±5 %RH of the station %RH datalogger reading.

h. If the station %RH datalogger reading does not agree with the Rotronic GT-L within ±5 %RH, troubleshoot, repair, or replace the station sensor as necessary.

NOTE: The station sensor may need calibration by the designated calibrator if step h, above, does not resolve the discrepancy (see calibration procedure, Appendix U.3).

3. Station's %RH Sensor Accuracy Check Using Environmental Tectonics Psychro-Dyne Psychrometer Reference Meter

NOTE: Read instructions provided with Psychro-Dyne psychrometer before proceeding. The sensor accuracy quality control check should be completed sometime during the day when %RH is below 80%.

a. Check datalogger for outside temperature at station.

b. Set up the Psychro-Dyne Psychrometer and allow dry bulb temperature to equilibrate to outside temperature. (This should take approximately 10 minutes.)

c. Open the lid on the Psychro-Dyne Psychrometer and wet the wick with three to five (3-5) drops of distilled water.

d. Close the lid and turn the switch clockwise to start the battery-driven fan.

e. Place the meter as close to the radiation shield as possible while keeping it out of direct sunlight or any wind gusts. The unit can be placed horizontally or vertically, but if placed vertically, do not block the air inlet to the wick. The vertical position provides increased accuracy for reading the thermometer meniscus.

f. Track the wet bulb thermometer until it stabilizes. This should take less than 10 minutes.

g. Record both the wet and the dry thermometer reading on a piece of paper. These will be used later.

NOTE: The thermometers on the psychrometer are graduated in degrees Fahrenheit.

h. Determine the %RH with the nomograph that is provided with the psychrometer and record it on the Monthly Quality Control Maintenance Checksheet (Figure U.1.1.1).

i. Turn off the psychrometer by turning the switch counter clockwise.

j. Return immediately to the station and record the datalogger's %RH and OTEMP readings.

k. From the dry thermometer temperature noted in step e, calculate the equivalent temperature in degrees Centigrade and record it on the checksheet.

NOTE: Degrees Centigrade = 5/9 x (Degrees Fahrenheit - 32)

l. The determined %RH reading from the psychrometer, in step f, should agree within $\pm$10 %RH with the datalogger %RH reading recorded in step h.

m. If the station %RH datalogger reading does not agree with the psychrometer within $\pm$10 %RH, troubleshoot, repair, or replace the station sensor as necessary.

CALIFORNIA AIR RESOURCES BOARD
MONTHLY QUALITY CONTROL MAINTENANCE CHECK SHEET
METEOROLOGICAL INSTRUMENTATION

Location: Sacramento Month/Year: Aug 94'

Station Number: 12-345 Technician: R. Smith

RESULTANT WIND SPEED

DATE	TRANSLATOR CHECK (Knots) Zero	Full	DATALOGGER Knots	Volts
8/3	0.006	86.84	4.2	.0484
8/20	0.006	86.84	8.7	.1002

RESULTANT WIND DIRECTION

TRANSLATOR CHECK (Deg.) Zero	Half	DATA-LOGGER Deg.	Volts	VISUAL CHECK
0.00	179.9	264.2	.734	W
0.00	179.9	210.3	.675	SW

OUTSIDE TEMPERATURE

DATE	REF °C	TRANSLATOR CHECK (C) Zero	Full	CHART °C	DATALOGGER °C	Volts
8/3	22.3	-50.00	50.00	22	22.48	.738
8/20	19.4	-50.00	50.00	19	19.7	.699

INSIDE TEMPERATURE

REF °C	CHART °C	DATALOGGER °C	Volts
24	24	24.1	.487
25	25	25.3	.503

PERCENT RELATIVE HUMIDITY

DATE	TRANSLATOR CHECK (%RH) Zero	Full	CHART %RH	REFERENCE RH SENSOR %RH	DATALOGGER %RH	Volts
8/3	0.0	100.1	37	34.3	37.4	.374
8/20	0.0	100.1	43	45.7	43.7	.457

NO SOL RAD at Site

SOLAR RADIATION

TRANSLATOR CHECK (W/m2) Zero	Full	DATALOGGER 2 W/m	Volts

Figure J.1.1.1
Monthly Quality Control Maintenance Checksheet

OPERATOR INSTRUCTIONS:

1. Daily Checks: Review datalogger and strip charts.

2. Bi-Weekly Checks: Record datalogger and strip chart readings.
   Record translator check readings (MET ONE ONLY).
   RWS: Visually inspect sensor cups or propeller for damage.
   RWD: Visually inspect wind vane for damage and record estimated wind direction (N, SW, NE, etc.).
   Verify mast orientation (Relative to True North).
   RH: Check station sensor versus reference %RH sensor.
   OTEMP/RH: Radiation shield fan operating.
   SOL. RAD: Radiation sensor not shaded.

3. Monthly Checks: Complete monthly maintenance check sheet.
   SOL. RAD: Clean radiation sensor element.

4. Semi-Annual Checks: Calibration (Last Cal. Date: Jul 94')

5. As needed checks: Inspect and lubricate sensor cable connections with silicon based grease.
   Clean radiation shield housing.

Note: Resultant Wind Speed (RWS) and Resultant Wind Direction (RWD) datalogger readings will fluctuate, so operator should watch output for 15 - 20 seconds and record the average reading in the space provided. This value should be approximately ± 5 knots (RWS) and ± 30 degrees (RWD) of visual estimates.

Generally, %RH exceeds 70% during nighttime and early morning hours. Considering that the instruments are generally most accurate between 20% and 80% of their range. QC checks should be made sometime during the day when %RH is below 80%. If the difference between station RH sensor and the reference RH sensor (GT-L Hygroskop or Pyschro-dyne) is greater than 10% RH, then a problem may exist and the operator should troubleshoot to correct the problem. Station sensor filter cover may be excessively dirty.

DATE	COMMENTS OR MAINTENANCE PERFORMED
8/3	Cleaned radiation shield.

MLD-111 2 of 2 (9/94) Reviewed by: J. Jones Date: 9/2/94

Figure U.1.1.1 (cont.)
Monthly Quality Control Maintenance Checksheet

U.1.2 MAINTENANCE

U.1.2.1 CLEANING

Maintenance of the Rotronic MP 100C/TM-12R and Met One 083C relative humidity sensors consists of assuring that dirt does not prevent the sensor from properly determining the %RH reading. The following tasks should be performed by the operator at least once every six months. To save wear and tear on the meteorological equipment, this cleaning procedure should be coordinated with the calibration, preferably between the "As Is" and the "Final" calibration. However, if for some reason the calibration does not fall within one month of the six-month interval, the operator should proceed with the steps listed below.

1. Disable the %RH and OTEMP channels on the datalogger.

2. Turn off power to the sensor and the radiation shield.

3. Remove the entire aspirator unit (Rotronics) or sensor housing (Met One) from its mounting point.

4. Remove the sensor from the aspirator or sensor housing.

5. Gently clean the exterior of sensor as necessary. Use a dry or damp cloth only. **DO NOT WET THE SENSOR.**

6. Clean the interior and exterior surfaces of the radiation shields using a bottle brush and water.

7. If the nose piece on the actual %RH sensor appears excessively dirty, a new one should be installed. The old one should be returned to the shop where it should be cleaned in the ultrasonic cleaner.

   NOTE: Be especially careful of the components inside the nose piece. They are very small, fragile, and in the case of the Rotronics, have to be placed close together with the temperature chip midway, in vertical relation to the %RH composite leaf sensor. Use tweezers, since the components can become contaminated by the oils on one's hands when touched, and this contamination will not allow the sensor to properly determine the %RH reading.

8. After the radiation shield is dry, reinstall the sensor into the aspirator unit or sensor housing. The Rotronic sensor should be centered under the fan. The Met One sensor can be difficult to fit into its clips, but once in, it is easily pushed into the sensor housing.

9. Reinstall the aspirator or sensor housing in its original location.

10. Turn on power to the sensors and the fan.

    CAUTION: **Do not apply power until the fans are completely dry. The Rotronic 12 VDC fan is especially susceptible to failing when it has power applied and there** is **water in its electronics.**

11. Wait one hour for the sensor to equilibrate before checking the accuracy of the output. This check is performed using the Monthly Checks procedures described in Section U.1.1.3.

12. After it has been determined that the %RH and OTEMP datalogger outputs are correct, reenable the %RH and OTEMP channels on the datalogger.

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METEOROLOGICAL PARAMETERS PERCENT RELATIVE HUMIDITY SENSORS

MONITORING AND LABORATORY DIVISION

JANUARY l995

U.2.0 ACCEPTANCE TEST PROCEDURES

U.2.0.1 GENERAL INFORMATION

Before beginning acceptance testing of the %RH systems, read the operating manual thoroughly. Initiate an Acceptance Test Log (Figure U.2.0.1) and an Acceptance Test "Mini" Report (Figure U.2.0.2). Record the dates of the individual tests, problems, contacts with the manufacturer, and any other pertinent information on the Acceptance Test Log.

U.2.0.2 PHYSICAL INSPECTION

Unpack the %RH system and check for physical damage if this has not already been done. Verify that the system is complete and includes all options and parts required by the purchase order.

U.2.0.3. OPERATIONAL CHECKS

Operational checks should assure that the %RH sensors and the translators meet or exceed performance specifications stated by the vendor. In addition, the check-out should verify that the %RH sensor meets Prevention of Significant Deterioration (PSD) Standards for dew point temperature (Accuracy: better than 1.5 degrees Centigrade). Perform the following operational checks using a voltmeter, oscilloscope, and/or data logger, and record the results on the Acceptance Test "Mini" Report. These tests should be run in the range normally used in field operations.

1. Translator Test - Connect a recorder or voltmeter to the output of the translator. Verify that the translator correctly converts voltage to %RH.

2. Linearity - Verify that the translator voltage outputs are linear $\pm$3% across the full scale at a minimum of five points. Enter the results in the Acceptance Test "Mini" Report.

3. Range Test - Verify that the %RH system operates at the full %RH range scale stated in the vendor's specifications.

4. Accuracy - Verify that the %RH system accuracy meets or exceeds the vendor's specifications.

ACCEPTANCE TEST LOG

Make _____ Model _____ SN _____

Date	Action

Figure U.2.0.1
Acceptance Test Log

ACCEPTANCE TEST "MINI" REPORT

Make_____ Model_____ Date_____

SN_____ ARB_____ By_____

Reviewed_____

	Pass	Fail	Comments
I. Physical Inspection			
A. Shipping damage			
B. Electrical wiring			
C. Completeness			
II. Operational Test			
A. Translator			
B. Linearity			
C. Range			
D. Accuracy			
IV. Special Test			
V. Maintenance Performed			

FULL SCALE_____

LINEARITY

%FS	True Voltage	Indicated Voltage	Diff. True-Ind.	Comments

Average Diff. True - Ind. must be less than 1% of Full Scale

Linear Regression Slope_____ Intercept_____ Correlation_____

Figure U.2.0.2
Acceptance Test “Mini” Report

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METEOROLOGICAL PARAMETERS
PERCENT RELATIVE HUMIDITY SENSORS

MONITORING AND LABORATORY DIVISION

JANUARY 1995

U.3.0 CALIBRATION PROCEDURES

U.3.0.1 INTRODUCTION

Following are two procedures which cover the specifics needed to calibrate Rotronic MP-100C or TM-12R and Met One 083C percent relative humidity sensors. Also included is a Station %RH reference meter accuracy check and a calibration procedure for the Rotronic Hygroskop GT-L meter, which ARB uses for reference checks of %RH. These calibrations are to be performed on a six-month interval or after any maintenance. If the sensor cannot be adjusted to within $\pm$0.5 %RH of the standard, replace the sensor. These calibrations should allow an accuracy within the parameters listed in Section U.1.0.3, Theory of Operation.

NOTE: It is important that temperature be stable (close to 25°C) during calibration. Calibration should not be attempted in direct air streams, in direct sunlight, or in areas of continuous temperature change such as rooms with poor temperature regulation. Any temperature variation has an effect on the accuracy of the calibration. If necessary, shelter the probe and calibration device by putting them in a styrofoam box.

When calibrating the sensor, preference should always be given to using the appropriate factory calibration device and humidity standards. Environmental chambers and incubators are generally not suitable for generating a stable and uniform reference humidity for the purpose of calibration. Comparing and adjusting the unit with a reference instrument is usually very deceptive, even when this is being done inside an environmental chamber.

NOTE: Calibrations should always be performed with the system intact (i.e., sensor, cable, translator, and connections to the datalogger). This assures that the system, as installed, is operating within the proper parameters. However, with the cables going through a roof or several floors, sometimes it is impossible to get the sensor into an environmentally controlled room. Thus, it is okay to install an extension cable up to 25 feet with properly mating connectors. This should be enough to allow the sensor to be placed in an environmentally controlled room, but not add enough resistance to affect the sensor output.

U.3.0.2 ROTRONIC MP-100C OR TM-12R SENSOR

Preliminary Information

The Rotronic MP-100C and TM-12R measure ambient relative humidity with a C-80 Hygromer sensor which is connected to a capacitive bridge. The output from this bridge feeds an amplification and linearization circuit which processes the signal and then sends the final signal to the datalogger.

A calibration is performed by using a calibration device which is sealed over the humidity sensor tip. The sensor accuracy is verified by introducing a known %RH inside the calibration device using humidity salt solution standards.

The basic humidity calibration is done at three different %RH levels: 10 %RH, 35 %RH, and 80 %RH. They are performed in a particular order due to some adjustments affecting other responses (i.e., the 35 %RH adjustment will affect the 80 %RH).

Any needed adjustments are made using potentiometers. The potentiometers on the MP-100C are accessed by unscrewing the cable grip at the end of the unit and pulling it back over the cable.

The three screws located towards the tip of the unit are removed. The unit barrel is carefully pulled back over the cable to gain access to the printed circuit board. Figure U.3.0.2 shows the location and function of the different adjustment potentiometers.

The potentiometers on the TM-12R are accessed by removing the screws on the cover of the electronics box. The electronics box is located at the other end of the pigtail attached to the sensor housing. Figure U.3.0.3 shows the location and function of the different adjustment potentiometers.

Equipment

1. RIC calibration device

2. EA80 Humidity Standard (2 ampules & 2 pads)

3. EA35 Humidity Standard (1 ampule & 1 pad)

4. EAl0 Humidity Standard (1 ampule & 1 pad).

5. A protective insulated box or a thermos.

6. Deionized water and soft lint-free cloths.

7. Small flathead screwdriver.

Procedure

Note that the temperature calibration described in subsequent sections of this appendix should be performed first, and that if the temperature potentiometers are adjusted, the %RH sensor must be calibrated.

1. 80 %RH "As Is" Check

   a. Disable the %RH channel on the datalogger.

   b. Remove the sensor from the aspirator or sensor housing.

   c. Carefully remove the dust filter or nose piece from the sensor. Assure the two sensors are not damaged and are lightly touching each other. **Do not touch the sensors with your fingers.** Carefully insert the sensor end into the calibration device, making sure that the knurled receptacle is facing down. Screw the calibration device tightly against the o-ring on the sensor.

   d. Unscrew the knurled receptacle and place one fiber pad in it. The purpose of this pad is to prevent accidental spilling of the solution inside the calibration device or on the humidity sensor.

   e. Tap the top of one ampule of the 80 %RH solution, making sure that all the liquid drops to the bottom of the vial. Snap off the top and empty the contents on the fiber pad.

   f. Screw the knurled receptacle back on the calibration device, making sure that the solution does not come in contact with the sensor.

CAUTION: The calibration device should never be inverted. The knurled receptacle should always be facing down.

g. Place the sensor with the calibration device into an insulated protective device away from direct wind or temperature changes. Allow at least one hour to ensure that the calibration device and the sensor are in a state of equilibrium. Record the “As Is” reading of the %RH on the calibration form (Figure U.3.0.1).

h. Remove the knurled receptacle from the calibration device. Throw away the wet pad (non-reusable). Flush the receptacle with deionized water and thoroughly wipe it dry with a soft, lint-free cloth. Removal of all the old solution is important to avoid contamination of solutions subsequently used in the calibration device.

2. 35 %RH "As Is" Check and Final Calibration

a. Place one fiber pad in the knurled receptacle of the calibration device. Tap the top of one ampule of the 35 %RH solution, making sure that all the liquid drops to the bottom of the vial. Snap off the top and empty the contents on the fiber pad.

b. Screw the knurled receptacle back on the calibration device, making sure that the solution does not come in contact with the sensor.

c. Place the sensor with the calibration device into an insulated protective device away from direct wind or temperature changes. Allow up to 90 minutes to ensure that the calibration device and the sensor are in a state of equilibrium. Record the "As Is" reading of the %RH on the calibration form (Figure U.3.0.1).

d. If the "As Is" reading difference is greater than $\pm$5.0 %RH from the humidity standard, adjust the 35 %RH potentiometer to a value within $\pm$0.5 %RH from the humidity standard (see Figure U.3.0.2 or U.3.0.3). After each adjustment, allow at least 5 minutes for the reading to stabilize. Once the sensor reading has been adjusted to 35.0 %RH ($\pm$0.5 %RH), record this reading in the final section of the calibration form.

e. Unscrew the knurled receptacle from the calibration device. Throw away the wet pad (non-reusable). Flush the receptacle with deionized water and thoroughly wipe it dry with a soft, lint-free cloth.

3. 80 %RH Calibration

If the 35 %RH potentiometer was not adjusted or if the 80 %RH check was not greater than ±5.0 %RH different from 80 %RH, proceed to the 10 %RH "As Is" check and calibration section. Otherwise, follow the steps listed below in this 80 %RH calibration section.

a. Place one fiber pad in the knurled receptacle of the calibration device. Tap the top of one ampule of the 80 %RH solution, making sure that all the liquid drops to the bottom of the vial. Snap off the top and empty the contents on the fiber pad.

b. Screw the knurled receptacle back on the calibration device, making sure that the solution does not come in contact with the sensor.

c. Place the sensor with the calibration device into an insulated protective device away from direct wind or temperature changes. Allow at least one hour to insure that the calibration device and the sensor are in a state of equilibrium.

d. If the reading difference is greater than ±5.0 %RH from the humidity standard, adjust the 80 %RH potentiometer to a value within ±0.5 %RH from the humidity standard (see Figure U.3.0.2 or U.3.0.3). After each adjustment, allow at least 15 minutes for the reading to stabilize. Once the sensor reading has been adjusted to 80.0 %RH (±0.5 %RH), record this reading in the final section of the calibration form.

e. Unscrew the knurled receptacle from the calibration device. Throw away the wet pad (non-reusable). Flush the receptacle with deionized water and thoroughly wipe it dry with a soft, lint-free cloth.

4. 10 %RH "As Is" Check & Calibration

   a. Place one fiber pad in the knurled receptacle of the calibration device. Tap the top of one ampule of the 10 %RH solution, making sure that all the liquid drops to the bottom of the vial. Snap off the top and empty the contents on the fiber pad.

   b. Screw the knurled receptacle back on the calibration device, making sure that the solution does not come in contact with the sensor.

   c. Place the sensor with the calibration device into an insulated protective device away from direct wind or temperature changes. Allow at least one hour to insure that the calibration device and the sensor are in a state of equilibrium. Record the "As Is" reading of the %RH on the calibration form (Figure U.3.0.1).

   d. If the "As Is" reading difference is greater than $\pm$5.0 %RH from the humidity standard, adjust the 10 %RH potentiometer to a value within $\pm$0.5 %RH from the humidity standard (see Figure U.3.0.2 or U.3.0.3). Adjustments to the 10 %RH potentiometer do not affect the 80 %RH or 35 %RH settings. After each adjustment, allow at least 5 minutes for the reading to stabilize. Once the sensor reading has been adjusted to 10.0 %RH ($\pm$0.5 %RH), record this reading in the final section of the calibration form.

   e. Unscrew the knurled receptacle from the calibration device. Throw away the wet pad (non-reusable). Flush the receptacle with deionized water and thoroughly wipe it dry with a soft, lint-free cloth.

5. 0 %RH Calibration

   a. The 0 %RH calibration requires a special desiccant and a stabilization time of 3 to 4 hours. With the 10 %RH calibration, the readings are accurate within $\pm$2 %RH down to at least 5 %RH. Thus, it has been determined, until further notice, that the 0 %RH calibration is not necessary.

6. Carefully remove the ca1ibration device and assure that the two sensors are not damaged and are lightly touching each other. Reinstall a clean dust filter/nose piece.

7. Reinstall the sensor in the radiation shield, assuring it meets EPA Volume IV requirements. Reenable the %RH channel on the datalogger.

U.3.0.3 MET ONE 083C SENSOR

Preliminary Information

The Met One 083C measures ambient relative humidity with a capacitive sensor which is connected to a differential amplification circuit. The processed signal is sent to the datalogger.

The calibration is performed using a Vaisala HMK 11 humidity calibrator. The Vaisala HMK 11 humidity calibrator is a 4.5" x 5.5" x 7.5" sized box which contains two bottles for the %RH solutions and lids with various sized orifices which the sensor fits snuggly into. Whenever an orifice is not being used for calibrations, it should be kept closed with the appropriate rubber stopper. This will prolong the life of the solutions, since they will not evaporate into the atmosphere. The solutions are premixed by the person performing the calibration at least 24 hours prior to the calibration.

The solutions' accuracy is dependant on the preparer's diligence in mixing the solutions and checking that the proper levels are maintained. Once mixed, the solutions are good as long as a minimum of 10% of the solution is undissolved salt and the solution level is at the upper edge of the marker line. If the above guidelines are followed, the solutions should be within $\pm$2.0 %RH of the %RH listed in Table U.3.0.2.

The humidity calibration is done at two different reference humidities: 11.3 %RH and 75.3 %RH. If the temperature shown in the calibrator deviates more than 3°C from 25°C, the exact reference humidity will change a slight amount. Thus, it is important to check the calibrator thermometer and read the equivalent %RH from the table on the calibrator.

Note: The 11.3 %RH solution should never be used or stored in temperatures below 18°C.

During calibration of the Met One 083C sensor, the low %RH potentiometer affects the high %RH potentiometer, so it is necessary to take the two "As Is" readings first. No particular order is required. To adjust the potentiometers, unscrew the nosepiece and slide the cover off. Be very careful not to damage the sensor which is exposed when the nosepiece is removed. R15 is labeled "zero" and adjusts the low %RH, and R18 is labeled "scale" and adjusts the high %RH. Do not adjust the potentiometer labeled "clamp".

The old style Met One 083C sensor uses the same calibration procedure, except that the access to the potentiometers is different. The potentiometers are accessed by removing the two flip-out access covers marked high or wet and low or dry on the exterior of the sensor. R18 is the high %RH potentiometer and R15 is the low %RH potentiometer.

Equipment

1. Vaisala HMK 11 humidity calibrator

2. 11.3 %RH salts, lithium chloride (LiCl)

3. 75.3 %RH salts, sodium chloride (NaCl)

4. Deionized water and soft, lint free cloths

5. Small 1/8" flathead screwdriver

Procedure

Note that the 083C is a self-contained sensor and does not rely on the station's temperature sensor, which is usually located adjacent to the %RH sensor. The temperature sensor in the %RH sensor is fixed and cannot be calibrated.

1. Vaisala HMK 11 Humidity Calibrator Preparation

    a. Both solutions are prepared in the same manner, so only instructions for LiCl will be given. Just repeat steps b, c, and e for the NaCl solution.

    b. Pour distilled or deionized water in the LiCl bottle until the water level reaches the bottom edge of the black marker line.

c. Sprinkle the lithium chloride in small quantities in the bottle, stirring constantly, until the liquid reaches the top edge of the marker line.

d. When dissolving, the LiCl solution warms up. Therefore, it is recommended to keep the solution bottle in a cold water bath during mixing.

CAUTION: Never add water to dry LiCl salts as it can heat up so rapidly that it splashes out from the bottle.

e. Let the solutions sit for at least 24 hours prior to using for any calibrations.

Prior to proceeding with the following procedure, check the station operator's present monthly maintenance checksheet to assure that the PC-Board's zero and full-scale readings are within the required parameters. Refer to Section U.1.1.3, Part 1 for procedures.

2. 11.3 %RH "As Is" Check

a. Assure that the 11.3 %RH solution is at its proper level in the bottle before proceeding.

b. Disable the %RH channel on the datalogger.

c. Remove the station sensor from the aspirator or the sensor housing.

d. Remove the rubber stopper from the lid on the 11.3 %RH solution bottle. Remove the nose piece from the sensor and carefully place the sensor into the hole, nose first.

e. It is important that the sensor be within 1°C of the room temperature. Once the temperatures are the same, it should take less than 10 minutes stabilization time for the sensor to be reading the percent humidity in the saturated salt solution head space. Once the reading has stabilized, record the reading on the calibration data sheet in the "As Is" section (Figure U.3.0.1).

f. Read the temperature from the thermometer on the humidity calibrator. Then use the table on the calibrator to determine the solution's actual %RH reading. Record this on the calibration data sheet (Figure U.3.0.1).

g. Remove the sensor from the hole in the lid and replace the rubber stopper.

3. 75.3 %RH "As Is" Check

a. Assure that the 75.3 %RH solution is at its proper level in the bottle before proceeding.

b. Remove the rubber stopper from the lid on the 75.3 %RH solution bottle. Place the sensor into the hole, nose first.

c. It should take less than 90 minutes stabilization time for the sensor to be reading the percent humidity in the saturated salt solution head space. Once the reading has stabilized, record the reading on the calibration data sheet in the "As Is" section (Figure U.3.0.1).

d. Read the temperature from the thermometer on the humidity calibrator. Then use the table on the calibrator to determine the solution's actual %RH reading. Record this on the calibration data sheet.

4. 75.3 and 11.3 %RH Calibrations

a. If the 75.3 %RH "As Is" reading difference is more than $\pm$5.0 %RH from the solution's actual %RH reading, adjust the sensor's R18 potentiometer (labeled either high, wet, or scale) to within $\pm$0.5 %RH of the solutions actual reading.

b. If the 11.3 %RH "As Is" reading difference is more than $\pm$5.0 %RH from the solution's actual %RH reading or potentiometer R18 was adjusted, place the sensor into the lid of the 11.3 %RH solution bottle. Adjust potentiometer R15 (labeled either low, wet, or zero) to within $\pm$0.5 %RH of the solutions actual reading after a 90-minute equilibration time.

c. Each potentiometer affects the other. Thus, the sensor needs to be placed back and forth into each solution bottle and the appropriate potentiometer adjusted until each reading is within ±0.5 %RH of the solutions' actual %RH reading.

d. Once the high and low %RH readings are within ±0.5 %RH of the respective solution, record the two readings in the final sensor %RH output section of the calibration data sheet.

e. Remove the sensor from the calibrator, reinstall the access covers or place the outer tubing over the PC board, and install a new or cleaned nose piece. Reinstall the sensor in the aspirator or sensor housing, assuring it meets EPA Volume IV requirements. Reenable the %RH channel on the datalogger.

U.3.0.4 STATION %RH REFERENCE METER

The following check is made to help assure that the station operator's %RH reference meter has not drifted too far to give accurate readings.

1. Place the station operator's %RH reference meter and the calibrator's %RH reference meter within 5 inches of each other. Allow both reference meters to equilibrate to the environment. Assure they are protected from temperature changes and drafts.

2. After the two readings have stabilized, record both reference meters' %RH readings on the calibration data sheet.

3. If the difference between the two meters is greater than ±5.0 %RH, the station operator's reference meter must be calibrated or replaced.

U.3.0.5 ROTRONIC HYGROSKOP GT-L METER

Preliminary Information

The calibration of the Hygroskop GT-L is performed using a 50 %RH standard every 6 months. For more accurate calibration within the range of 10 to 90 %RH and any calibration of the resistance temperature detector (RTD), the Hygroskop GT-L must be returned to the factory on an annual basis.

The calibration is performed in a room at constant temperature and without any thermal effects which may interfere with the calibration (i.e., air drafts, sun rays, heater, fan, etc.). The sensor and its calibration device should be placed on a surface which does not easily change its temperature, such as the styrofoam cover to the 50 %RH calibration kit. This will assist in maintaining a temperature equilibrium between the sensor and the work surface.

Equipment

1. RIC GT-L calibration device

2. EA50 Humidity Standard (1 ampule & 1 pad)

3. Calibrated thermometer (The inside temperature [ITEMP] reading can be used if it has been recently calibrated.)

4. Deionized water and soft, lint-free cloths

5. Small 1/8" flathead screwdriver

Procedure

1. Unscrew the knurled receptacle of the calibration device.

2. With the dust filter left on, insert the probe well inside the calibration device and tighten the sealing ring.

3. Place a fiber pad in the knurled receptacle of the calibration device and empty the contents of one 50 %RH solution ampule on it.

4. Hold the calibration device with the opening facing downwards and screw the knurled receptacle back into position. Assure it is tightly closed against the o-ring.

   Note: Keep the calibration device knurled receptacle oriented downwards to make sure that the solution does not come in contact with the probe during and after the calibration.

5. After the output has stabilized, usually within 40 minutes, record the "As Is" reading on the Rotronic Hygroskop GT-L calibration data sheet (Figure U.3.0.5).

6. If the reading is more than $\pm$0.5 %RH off from 50 %RH, remove the access cover from the front of the meter and adjust the potentiometer. Once the output is reading within $\pm$0.5 %RH of 50 %RH, replace the cover and record the final reading on the calibration data sheet. Note that it will take about 5 minutes after each potentiometer adjustment for the reading to stabilize.

7. After the final reading is taken, unscrew the knurled receptacle and throw away the fiber pad. Remove the probe from the calibration device. Wash and dry the calibration device to remove any solution residue.

8. Place the reference thermometer or ITEMP probe as near as possible to the probe of the GT-L, but not touching. It is suggested that the dust filter be removed for the following steps. This will allow for a more even response between the reference thermometer and the GT-L RTD.

9. Once the outputs of both thermometers have stabilized, record the two readings on the calibration data sheet. After five minutes, record the two readings again. Repeat this once more and then average the difference of the three s&ts of readings. If the average difference is greater than 1EC, send the Rotronic Hygroskop GT-L to the factory to be calibrated.

10. If the dust filter is dirty or damaged, replace it with a new one.

Note: A copy of the calibration data sheet should be carried with the GT-L or the data of the last calibration should be posted on the GT-L itself. This will alert the operator as to when the next six- month calibration is due.

California Air Resources Board
Percent Relative Humidity Calibration Datasheet

DATE _____ CALIBRATION: AS IS |___| FINAL |___|

SITE: Name _____ Number _____ Last Cal _____

INSTRUMENT DESCRIPTION:
RADIATION SHIELD:
Manufacturer _____
M.N. _____ S.N. _____ ARB # _____

SENSOR:
Manufacturer _____
M.N. _____ S.N. _____ ARB # _____

Datalogger Output:
Reporting Units _____ Range _____ Sensor Height _____

CALIBRATION EQUIPMENT:
Temperature/Relative Humidity Reference Sensor
Manufacturer _____ M.N. _____ S.N. _____

Calibration Device
Manufacturer _____ M.N. _____ S.N. _____

%RH chemical mixtures = _____%RH _____%RH _____%RH
Manufacturer _____ M.Ns. _____ _____ _____

CALIBRATION:
% RH Accuracy (If % difference is > 5%, adjust sensor to 0.5% of Standard)

Temperature Degree C	%RH Standard Value Input	AS-IS Sensor % RH Output VDC	AS-IS Sensor % RH Output %RH	% Diff.	FINAL Sensor % RH Output VDC	FINAL Sensor % RH Output %RH	% Diff.

Change from Previous Calibration: $\frac{\text{Avg. Diff.-Prev. Avg. Diff.}}{\text{Prev. Avg. Diff.}}$ X 100 = _____%

Linear Regression: Slope=_____, Intercept=_____, Correlation=_____

Ambient check with station %RH reference meter:
Station %RH Sensor= _____ %RH Reference %RH Sensor= _____ %RH
Difference= _____ %RH (Should be less than 5% RH)

Comments:_____

Calibrated by _____ Checked by _____

Figure U.3.0.1
Percent Relative Humidity Calibration Datasheet

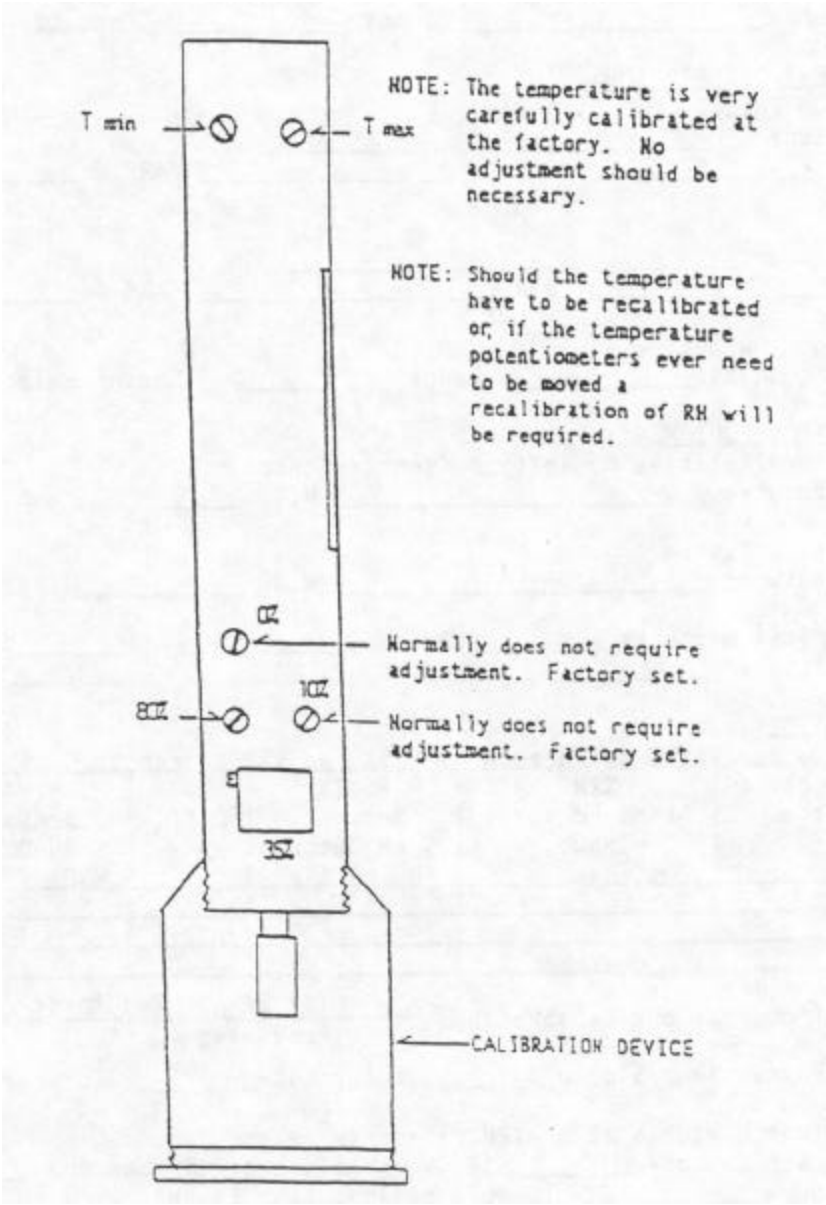

Figure U.3.0.2
Rotronic MP-100C with Calibration Device

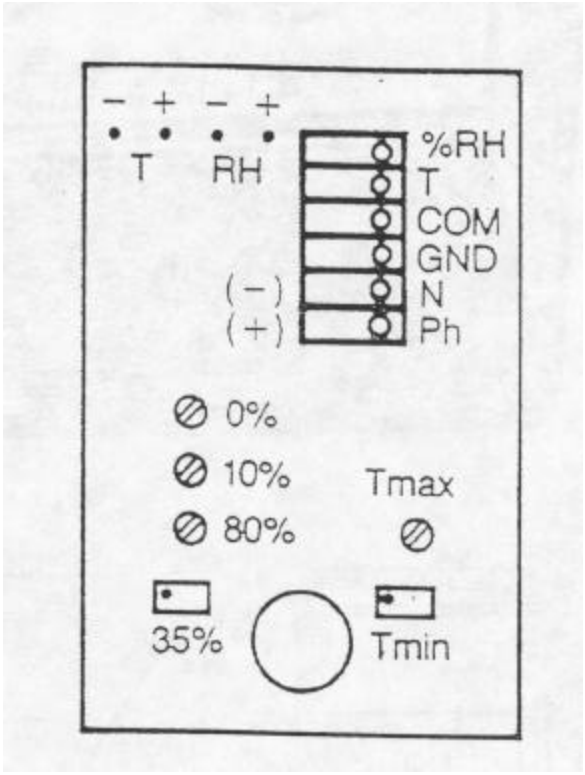

Figure U.3.0.3
Rotronic TM-12R P.C. Board Layout

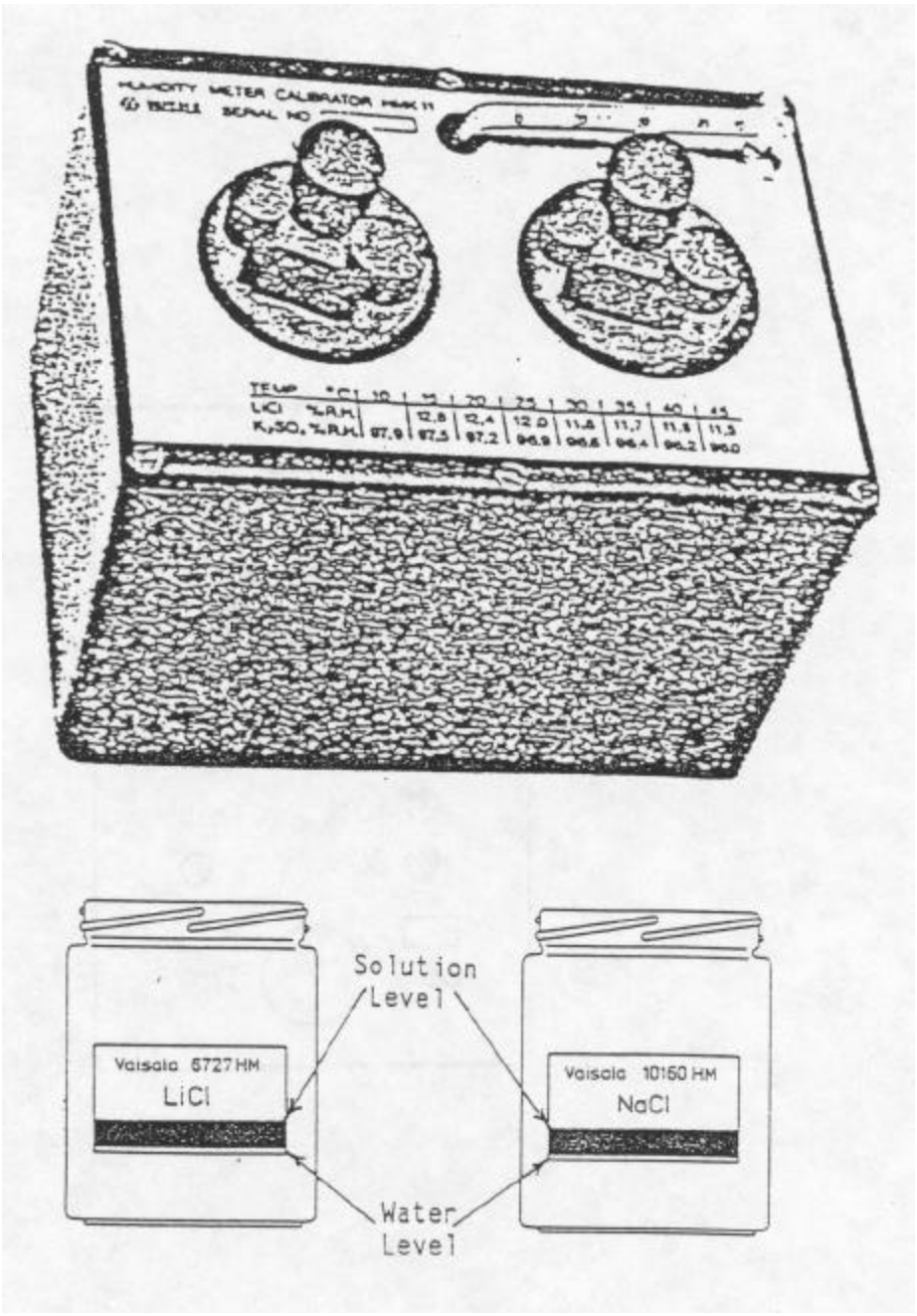

Figure U.3.0.4
Met One Relative Humidity Calibration Device

CALIFORNIA AIR RESOURCES BOARD
ROTRONIC HYGROSKOP GT-L PERCENT RELATIVE HUMIDITY/TEMPERATURE CALIBRATION

DATE _____ CALIBRATION: AS IS |___| FINAL |___|

INSTRUMENT DESCRIPTIVE INFORMATION:
Serial Number: _____
Last calibration date: _____
Last factory certification date: _____
Station operator: _____

CALIBRATION EQUIPMENT:
Calibration device
Manufacturer _____ M.N. _____ S.N. _____
%RH chemical mixture = _____ %RH
Manufacturer _____ M.N. _____ S.N. _____
Manufactured date: _____
Reference thermometer
Manufacturer _____ M.N. _____ S.N. _____
Last calibration date: _____ Slope= _____ Intercept=_____

PERCENT RELATIVE HUMIDITY CALIBRATION:
%RH accuracy (If "As Is" >0.5 %RH different, adjust to <0.5 %RH)

Temperature Degree C	%RH Standard Value Input	"As Is" Rotronic % RH Output	%RH Diff.	FINAL Rotronic % RH Output	%RH Diff.

Change from Previous Calibration: $\frac{\text{Avg. Diff.-Prev. Avg. Diff.}}{\text{Prev. Avg. Diff.}} \times 100 =$ _____ %

TEMPERATURE CHECK:
Temperature accuracy (If "As Is" >1.0°C different, return unit to factory)

Test Number	Time	Thermometer Reading	"As Is" Rotronic Temperature Output	Degrees C Difference
1				
2				
3				
4				
5				

Change from Previous Calibration: $\frac{\text{Avg. Diff.-Prev. Avg. Diff.}}{\text{Prev. Avg. Diff.}} \times 100 =$ _____ %

Comments: _____

Figure U.3.0.5
Rotronic Hygroskop GT-L Calibration Data Sheet

Table U.3.0.1
Rotronic Calibration Values

CALIBRATION VALUES

Relative Humidity		Temperature	
VDC	%RH	VDC	°C
0.0	0	0.0	-30
0.1	10	0.1	-20
0.2	20	0.2	-10
0.3	30	0.3	0
0.4	40	0.4	10
0.5	50	0.5	20
0.6	60	0.6	30
0.7	70	0.7	40
0.8	80	0.8	50
0.9	90	0.9	60
1.0	100	1.0	70

Table U.3.0.2
Met One Calibration Table

°C	Lithium chloride LiCl	Sodium chloride NaCl	Potassium sulphate K_2SO_4
0	*	75.5	98.8
5	*	75.7	98.5
10	*	75.7	98.2
15	*	75.6	97.9
20	11.3	75.5	97.6
25	11.3	75 3	97.3
30	11.3	75.1	97.0
35	11.3	74.9	96.7
40	11.2	74.7	96.4
45	11.2	74.5	96.1
50	11.1	74.4	95.8